TOWARD A THEORY OF MAESTHETICS: PRELIMINARY CONSIDERATIONS OF THE DESIRABILITY OF BRINGING AN AESTHETIC PERSPECTIVE TO MATHEMATICS, EDUCATION AND SOCIETY

William Higginson

Queen's University

This paper makes an argument for the recognition of 'maesthetics', a neologism for a perspective on the nature, teaching and learning of mathematics that emphasizes the human and aesthetic aspects of the discipline. A case is made for the need for alternative perspectives given the numerous detrimental effects at both the individual and societal levels of the 'standard' conception of the enterprise of mathematics teaching. Maesthetics is seen to have many features in common with ethnomathematics, with the essential difference lying in its focus on the individual rather than the societal level of activity. Existing work from a range of scholarly fields that might contribute to the foundations of such an enterprise are noted. Some characteristics are suggested and examples are given.

CAVEAT LECTOR

In the spirit of forewarning the reader, it is perhaps as well to say at its beginning, that this paper is not, from the perspective of conventional scholarly publication, orthodox. It attempts to stay within the very reasonable stylistic recommendations of the editors but it strays a long way from the conventional norms of a focused, coherent, tightly argued and precisely documented argument easily placed with respect to context and methodology. Given that one of the major aims of the paper is to suggest that mathematics educators badly need to broaden their conceptions of what their enterprise attempts to do, this may not be entirely negative. Using the terminology of the philosopher and historian of science, Thomas Kuhn, the paper might be considered a plea for the consideration of a different, or at least another, alternative 'paradigm' for the nature, teaching and learning of mathematics. It is clear that this aim is ambitious and that this particular statement represents an early stage of development. Another ambition, in the spirit of the view sometimes attributed to Karl Popper, namely that, 'the purpose of a professor is to provoke', is to generate discussion

THE PLACE OF MATHEMATICS EDUCATION IN SOCIETAL CHANGE

A panoptic and interesting perspective from which to consider the place of mathematics with respect to society and education was articulated by the distinguished political philosopher, Isaiah Berlin, in an address he gave on being awarded the first Agnelli Prize in 1988. In the opening paragraphs of this address that was later published under the title "On the Pursuit of the Ideal" (1991) he wrote:

J.F. Matos, P. Valero & K. Yasukawa (Eds.) (2008). *Proceedings of the Fifth International Mathematics Education and Society Conference*. Lisbon: Centro de Investigação em Educação, Universidade de Lisboa – Department of Education, Learning and Philosophy, Aalborg University.

> There are, in my view, two factors that, above all others, have shaped human history in this century. One is the development of the natural sciences and technology, certainly the greatest success story of our time - to this, great and mounting attention has been paid from all quarters. The other, without doubt, consists in the great ideological storms that have altered the lives of virtually all mankind: the Russian Revolution and its aftermath - totalitarian tyrannies of both right and left and the explosions of nationalism, racism, and, in places, religious bigotry, which, interestingly enough, not one among the most perceptive thinkers of the nineteenth century had ever predicted. … When our descendants, in two or three centuries' time (if mankind should survive until then), comes to look at our age, it is these two phenomena that will, I think, be held to be the outstanding characteristics of our century, the most demanding of explanation and analysis. …. The goals and motives that drive human action must be looked at in the light of all that we know and understand, their roots and growth, their essence, and above all their validity, must be examined with every critical resource that we have. (Berlin, 1990, pp. 1-2)

Berlin's exhortation is powerful, and one obvious place to start a mathematics educator's explanation and analysis of 'the goals and motives that drive human action' is with a consideration of how our discipline is connected to the logical geography (to use a phrase of another late Oxford philosopher, Gilbert Ryle) of science and technology and ideological storms. I want to contend that we have been - consciously or not - exceptionally close to the intersection of these two forces.

No informed consideration of the development of twentieth century science and technology could do anything other than recognize the centrality of mathematical concepts and structures. Mathematics has provided not just the backbone for science and technology but also, in the 'information age', its nervous system as well (Davis & Hersh, 1986). On the educational side of our mandate the responsibility is perhaps less sharply outlined. However, I think it not a very large step in the era of 'multicultural' societies to argue, even in jurisdictions where there are no explicit statements to that effect, that one of the major aims of the educational enterprise is to teach people to coexist peacefully. And if we have, as I claim above, been close to the centre of things, what has our contribution been? At the end of some grand, Berlinesque, reckoning of moral responsibility for the development of the modern era, do mathematics teachers and mathematicians find themselves aligned with the forces of light or of darkness? This is clearly an impossible question to answer definitively, and even a cursory consideration would generate a large number of examples of conflicting contributions. The case for the prosecution - that is to say, arguing for the position that mathematics education as conventionally manifested, is 'guilty' of contributing in an essentially negative way to historical development - would, I think, be very strong.

To sharpen this image let us imagine a ‘revised’ edition of Berlin’s vision. Two decades later the ideological storms have intensified considerably, and the parlous realities of environmental degradation are swiftly becoming more evident (Homer-Dixon, 2006; Monbiot, 2006) as the most pressing front in the world of science and technology. Keeping these contemporary realities in mind and switching our imaginary gaze to some ‘typical’ classroom where pliable young minds are being introduced to a range of ‘languages’ that, at least in theory, will assist them in future interactions with others and the world. If, according to all the best techniques of statistical sampling, our selected classroom is highly ‘representative’, how confident might we be that the mathematical component of their day is going to be positive? From this perspective perhaps the case for the prosecution suggested above becomes easier to imagine because the ‘client satisfaction’ levels among mathematics learners have historically been and continue to be very low (Tobias, 1993). One way in which these views are reflected are in research studies that ask respondents to share their images of mathematicians. The historical trends in this exercise are of concern. Forty years ago British psychologist, Liam Hudson found that English schoolboys found the Mathematician to be "even colder, duller and less imaginative than the Physicist." (Hudson, 1970, p. 48). Some thirty years later Susan Picker and John Berry (2000) found that school children from several countries had consistently negative images of mathematicians and that it was not uncommon for their drawings to incorporate aspects of violence.

Research carried out by Nardi and Steward (2003) with lower-form secondary school students in England gave some unusually clear insights into the sources of pupil dissatisfaction. In their paper they captured some elements of the discontent with the acronymic “T.I.R.E.D.” with the five factors being, respectively, Tedium, Isolation, Rote learning, Elitism and Depersonalisation. The skill with which this piece of work was carried out - it is not easy to gain the confidence of this age group in a school setting - and the well written paper that reported it contributed to a significant sense of authority. In our current age of ‘globalization’ there was also a strong feeling - paralleling the findings of Picker and Berry who found a high degree of consensus across geographic boundaries - that the views of the English adolescents were essentially isomorphic to those of their age cohort in many other parts of the world. The fact that some particular teaching enterprise is not getting good reviews with adolescents is not, in itself, cause for concern. Should, however, their unease reflect a disconnection with fundamental human values the issue would need to be taken much more seriously. If many of our children see our subject as one that is narrow, cold, boring, dehumanized and mechanistic we cannot realistically expect them to function at a high level in a world that is increasingly built on this discipline. Hidden just under the surface of Nardi and Steward’s sensitive report of quiet disaffection is one almost completely ignored dimension of contemporary mathematics education. The majority of responsible educators are, rightly, very concerned about the depressingly

high percentage of learners who fail quite conspicuously to gain any significant level of competence in mathematics. What gets very little attention is that even those who are ‘successful’ by the conventions of the enterprise are very frequently taking away a thin and brittle version of the subject. They may have jumped all the requisite hoops necessary to obtain a credit, but it would be an optimistic employer who would expect any degree of comfort with anything outside a narrowly proscribed range of applicability. Nor would the chance of their seeing the discipline as anything beyond a collection of techniques be very large.

FROM MUSIC TO MAESTHETICS

To gain some perspective on this issue let us consider some parallels between mathematics and music. Despite the fact that it is frequently noted that the two areas have many common features, their public presences are almost diametrically opposed. For most people mathematics is exclusively identified with a particular type of institutional setting and rituals. For music the corresponding ‘school’ structures represent a very small subset of the total disciplinary presence in the culture. There certainly are courses and examinations, but they are associated much more often with free choice and they are relatively unimportant for most citizens who may or may not choose to participate in some way with a cornucopia of musical offerings. Some people find that the string quartet meets all of their musical needs but other have a dazzling range of other choices including folk, jazz, choral, country, blues, and orchestral. The situation in mathematics is not quite the equivalent of ‘string quartets or nothing’, but it certainly is in that direction.

So what might be done to try to move mathematics in the direction of music in the sense of broadening the range of styles? If this could be done, might it, at least for some learners, some of the time, lead to more satisfying experiences in mathematics education? I believe that the answer to both of these questions is yes, and in the remaining pages of this paper I would like to outline what at least one of these alternatives might look like. For reasons that will emerge shortly I propose to give the name ‘maesthetics’ to this particular approach to mathematics and its teaching and learning with the intention of clearly marking the fact that it is a merging of math and aesthetics. Its conception has been influenced in a constructive way by the conscious attempt at combating the ‘fatigue’ of ‘T.I.R.E.D. ness’.

MAESTHETICS AS A STYLE OF MATHEMATICS

As a first central characteristic of maesthetics let us stress its human element. Unlike classical, or orthodox mathematics where texts and symbols are omnipresent and creative thinkers almost invisible (note the ‘D’ for Depersonalised in T.I.R.E.D.), in maesthetics the role of the creative individual is to be stressed. The elitism mentioned by the students interviewed by Nardi and Steward is a reflection of the common view built into conventional mathematics teaching that it is a pursuit, at anything other than a functional level, for a small minority. The distribution of attitudes toward

mathematics is, in the conventional view, quite naturally highly skewed, with only a few capable of a full appreciation of the subject. Maesthetics will proceed from the assumption that mathematics, like music, is open for active appreciation, perhaps in many different forms by most people. A second central characteristic is a pervasive sense of play. In the spirit of Huizinga's *homo ludens* we will encourage students of maesthetics to shuck off the utilitarian shackles of conventional mathematics. There are two reasons for thinking that this is not entirely unrealistic. The first is the exceptional impact of one outstanding writer in the field of recreational mathematics, Martin Gardner. For almost three decades Gardner wrote a column in *Scientific American* called *Mathematical Games* and it is now almost commonplace to have prominent research mathematicians in their autobiographical writing credit their passion for mathematics to their early exposure to Gardner's columns. The second is the quite remarkable attraction of a class of mathematical puzzles and games for a very wide spectrum of the population. In recent years it has been the logic puzzle, Sudoku, but it would seem that every decade has its particular example. The '15' puzzle fascinated one generation just as Mr. Rubik's contraption did another.

FOUNDATIONS FOR MAESTHETICS - EVOLUTIONARY & CULTURAL

One of the most popular approaches to the development of new perspectives across a number of academic fields in recent decades has been the technique of looking at a discipline from an evolutionary perspective. The most high profile of these investigators have worked in fields like biology (Wilson, 1975), psychology (Barkow, Cosmides & Tooby, 1995) and linguistics (Pinker, 2002). Perhaps more surprisingly, evolutionary speculation has been the centre of much activity in fields such as history (Smail, 2007), music (Levitin, 2007), and literary theory (Gottschall & Wilson, 2005). There has been research carried out from this perspective with respect to mathematics, particularly near its boundary with developmental psychology (Butterworth, 1999; Dehaene, 1997; and Devlin, 2000). The most ambitious effort in this sub-field was the attempt from a philosophical/linguistic perspective by Lakoff and Nunez (2000) to account for the generation of mathematics by an 'embodied mind'. The speculations of the distinguished mathematician Saunders Mac Lane (1986) about the origins of mathematics in "human cultural activities" might also be placed in this category.

With respect to generating foundational ideas for maesthetics, however, the richest source of ideas is the work of the American anthropologist, Ellen Dissanayake. In three significant books published over a period of fifteen years Dissanayake delved deeply into the role of art in human culture and cognition. In the second of these publications, *Homo aestheticus* (1995) she proposed that humans are by their nature, aesthetic beings. She makes this claim having examined many situations where humans are predisposed to have a sensitivity to, and attraction toward, concepts like symmetry, pattern and balance. The neologism, 'maesthetics' (and the related idea of *homo maestheticus*) is derived directly from this work by extending the observation

that these same predispositions can be seen as fundamental to the generation of mathematical ideas.

Dissanayake's documentation of the pattern-rich decorative and artistic production of many human groups brings her very close to the work of ethnomathematicians like Zazlavsky (1979), Eglash (1999) and Gerdes (1998). And this, in turn, points to one potential benefit of developing another 'alternative perspective' on mathematical activity. Ethnomathematics has been a rich and fascinating field of work for a small group of talented scholars (D'Ambrosio, 1985; Joseph, 1991; Powell & Frankenstein, 1997) over the last three decades. However, when it has been seen as a 'replacement' for the conventional perspective criticism has been savage. If it was to be seen as one of a range of 'supplementary' emphases, it might be accepted more easily.

FOUNDATIONS FOR MAESTHETICS - PRECURSORS AND PIONEERS

There are many teachers, researchers and curriculum developers whose work would, at least in part, be consistent with a maesthetic perspective. In this closing section I point briefly to some of these sources. The world of recreational mathematics has already been mentioned. From the viewpoint of the philosophy of education generally, the work of Alfred North Whitehead stands out (1926, 1967). His idea of the 'rhythms' of education, with its identification of the cycle of 'romance, precision and generalization' is particularly apt. One way of characterizing maesthetics would be to note that, from this Whiteheadian perspective, it accentuates the stage of romance. Conventional curricula have a great deal of 'precision' work, a little generalization, and almost no romance. In previous work (Higginson, 1999) I have suggested that mathematics educators would have been much wiser to follow the process orientation of Whitehead rather than committing themselves to the sharp edges of the certainty and logic obsessed Bertrand Russell. Among contemporary philosophers of mathematics education Paul Ernest's work (1991) is especially stimulating. His model of ideologies of mathematics education could be adapted relatively easily to support the development of a theory of maesthetics. [It is interesting to note how few curriculum materials have incorporated Ernest's message in any explicit sense. For an interesting counter example see Roulet's *Math Towers* (2007)]. The emphasis on the visual in maesthetics could draw on the rich source of examples in works like those of Alsina & Nelson (2006). Bruner's ideas of the tripartite forms of representation provides a good underpinning for an emphasis on the 'iconic' and the 'enactive' as well as the 'symbolic' which is the almost exclusive form of conventional texts. This also provides a direct bridge to the visual potential of new information technology and Whitehead's rhythms mentioned above. The potential for giving 'human glimpses' of mathematics and mathematicians is greatly increased with the evolution of the internet. Short visits to the websites of Tao, Demaine, duSautoy, and Conway would do much to counter any view that mathematicians are a boring, self-obsessed and inarticulate group.

It would be possible to interpret much of at least the early years of the 'investigative' era of secondary mathematics education in the United Kingdom (Boaler, 1997) in maesthetic terms. Other rich sources include the classic *Starting Points* (Banwell, Saunders, & Tahta, 1972) and Orton's fine collection (1999) on *Pattern in the Teaching and Learning of Mathematics.*

The math/art interface has been extensively mined historically (Emmer, 1993) and some of that literature is consistent with maesthetics. The very active 'Bridges' group has produced some very interesting math/art materials in the Proceedings documents from their annual meeting (Sarhangi & Moody, 2005).

Several members of the Mathematics, Science and Technology Education Group at Queen's University have been involved in projects which have had - without it explicitly being articulated that way - a maesthetic foundation. These include a Vision Statement Project, *Tomorrow's Mathematics Classroom*, that looked at the implications for teachers and students of considering mathematics to be at tool, a language and an art. The book, *Creative Mathematics* by Upitis, Phillips and Higginson (1997) documented the work of a gifted elementary teacher using a variety of innovative ("constructive aesthetic") teaching approaches. More recently, the doctoral work of Nathalie Sinclair (2006) has been published (in extended form) by Teachers College Press under the title, *Mathematics and Beauty: Aesthetic Approaches to Teaching Children*. Many of the ideas in this paper are considered at greater length and from different perspectives in an edited collection entitled *Mathematics and the Aesthetic: New Approaches to an Ancient Affinity* (Sinclair, Pimm & Higginson, 2006), especially Higginson (2006).

EPILOGUE

In the spirit of the visionary artist: from deep in the bowels of one of the great American novels of our age.

> We have an idea, some of us, that's taking shape. A new sort of collegium. Closer contact, minimal structure. We may teach Latin as a spoken language. We may teach mathematics as an art form like poetry or music. We will teach subjects that people don't realize they need to know. All this will happen somewhere in the hinterland. Don DeLillo, *Underworld*, (1997), p. 675.

REFERENCES

Alsina, C. & Nelson, R. B. (2006). *Math made visual: Creating images for understanding mathematics.* Washington, DC: Mathematical Association of America.

Banwell, C. S., Saunders, K.D. & Tahta, D. G. (1972). Starting points for teaching mathematics in middle and secondary schools. Oxford: Oxford University Press.

Barkow, J. H., Cosmides, L. & Tooby, J. (Eds.). (1995). The adapted mind: Evolutionary psychology and the generation of culture. New York: Oxford University Press.

Berlin, I. (1990). The crooked timber of humanity: Chapters in the history of ideas. London: John Murray.

Boaler, J. (1997). Experiencing school mathematics: Teaching styles, sex and setting. Buckingham, UK: Open University Press.

Butterworth, B. (1999). What counts: How every brain is hardwired for math. New York: The Free Press.

D'Ambrosio, U. (1985). Ethnomathematics and its place in the history and pedagogy of mathematics. For the Learning of Mathematics, 5(1), 41-48.

Davis, P. J., & Hersh, R. (1986). Descartes' dream: The world according to mathematics. Boston: Houghton Mifflin.

Dehaene, S. (1997). The number sense: How the mind creates mathematics. New York: Oxford University Press.

DeLillo, D. (1997). Underworld. New York: Simon & Schuster.

Devlin, K. (2000) The math gene: How mathematical thinking evolved and why numbers are like gossip. New York: Basic.

Dissanayake, E. (1995). Homo aestheticus: Where art comes from and why. Seattle: University of Washington Press.

Eglash, R. (1999). African fractals: Modern computing and indigenous design. New Brunswick, NJ: Rutgers University Press.

Emmer, M. (Ed.). (1993). The visual mind: Art and mathematics. Cambridge, MA: MIT Press.

Ernest, P. (1991). The philosophy of mathematics education. Basingstoke, UK: Falmer.

Gerdes, P. (1998). Women, art and geometry in Southern Africa. Trenton, NJ: Africa World Press.

Gottschall, J., & Wilson, D. S. (Eds.). (2005). *The literary animal: Evolution and the nature of narrative.* Chicago: Northwestern University Press.

Higginson, W. (1999). Glimpses of the past, images of the future: Moving from 20th to 21st century mathematics education. In C. Hoyles, C. Morgan, & G. Woodhouse (Eds.), *Rethinking the Mathematics Curriculum.* (pp. 184-194) London: Falmer.

Higginson, W. (2006). Mathematics, aesthetics and being human. In Sinclair et al. op cit. (pp. 126-142).

Homer-Dixon, T. (2006). *The upside of down: Catastrophe, creativity and the renewal of civilization.* Toronto, Knopf.

Hudson, L. (1970). *Frames of mind: Ability, perception and self-perception in the arts and sciences.* Harmondsworth, UK: Penguin.

Joseph, G. G. (1991). *The crest of the peacock: Non-European roots of mathematics.* Harmondsworth: Penguin.

Lakoff, G., & Nunez, R. (2000). *Where mathematics comes from: How the embodied mind brings mathematics into being.* New York: Basic.

Levitin, D. (2007). *This is your brain on music.* New York: Plume.

Mac Lane, S. (1986). *Mathematics: Form and function.* New York: Springer-Verlag.

Monbiot, G. (2006). *Heat: How to stop the planet from burning.* Toronto: Doubleday.

Nardi, E., & Steward, S. Is mathematics T.I.R.E.D.?: A study of quiet disaffection in the secondary mathematics classroom. *British Educational Research Journal,* 29(3), 345-367.

Orton, A. (Ed.). (1999). *Pattern in the teaching and learning of mathematics.* London: Cassell.

Picker, S. H., & Berry, J. (2002). Investigating pupil's images of mathematicians. *Educational Studies in Mathematics,* 43(1), 65-94.

Pinker, S. (2002) *The blank slate: The modern denial of human nature* New York: Viking.

Powell, A. B., & Frankenstein, M. (Eds.). (1997). *Ethnomathematics: Challenging Eurocentrism in mathematics education.* Albany: State University of New York Press

Roulet, G. (2007). *Math Towers.* An online interactive environment. http://www.math-towers.ca/.

Sarhangi, R. & Moody, R. V. (Eds.). (2005). *Renaissance Banff: Mathematics, music, art, culture.* Proceedings of the 2005 'Bridges' conference. Winfield, KS: Southwestern College.

Sinclair, N. (2006). *Mathematics and beauty: Aesthetic approaches to teaching children*. New York: Teachers College Press.

Sinclair, N., Pimm, D., & Higginson, W. (Eds). (2006). *Mathematics and the aesthetic: New approaches to an ancient affinity*. New York: Springer-Verlag.

Smail, D. L. (2007). *On deep history and the brain.* Berkeley: University of California Press.

Tobias, S. (1993) *Overcoming math anxiety.* (Revised and expanded edition.) New York: Norton.

Upitis, R., Phillips, E., & Higginson, W. (1997). *Creative mathematics: Exploring children's understanding,* London: Routledge.

Whitehead, A. (1967) *The aims of education and other essays.* New York: Free Press.

Whitehead, A. (1926) *Science and the modern world.* New York: Macmillan.

Wilson, E. O. (1975). *Sociobiology: The new synthesis.* Cambridge: Harvard University Press.

Zazlavsky, C. (1979). *Africa counts: Number and pattern in African culture.* Westport, CN: Lawrence Hill.